SCIENCE

VOL. 73 | FRIDAY, MAY 1, 1931 | No. 1896

SCIENCE: A Weekly Journal devoted to the Advancement of Science, edited by J. MCKEEN CATTELL and published every Friday by

THE SCIENCE PRESS

New York City: Grand Central Terminal

Lancaster, Pa. | Garrison, N. Y.

Annual Subscription, $6.00 | Single Copies, 15 Cts.

SCIENCE is the official organ of the American Association for the Advancement of Science. Information regarding membership in the Association may be secured from the office of the permanent secretary, in the Smithsonian Institution Building, Washington, D. C.

SUGARS IN THE SERVICE OF CHEMISTRY[1]

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SUGARS are the most popular topic of chemical literature to-day. There must be a reason for it, and the question arises—What is it? The importance of carbohydrates in our daily life, the numerous uses made of them in our foodstuffs, in textiles, in building materials, in the many substitutes for the more costly natural products may sound like a logical answer to the question. Indeed, it may be claimed that the progress of civilization can be measured by the extent of the uses made of carbohydrates for constructive and destructive purposes. Yet the answer would be only partially correct. It would be hard to believe that men of the type of Scheele, Baeyer, Fischer and van't Hoff devoted themselves to the problems of sugar chemistry for reasons purely practical.

[1] Delivered before the Chemical Society of Washington on the occasion of the award of the Hillebrand Prize to C. S. Hudson, March 26, 1931.

Admitting even for the sake of argument that to many workers the incentive was the applied phase of sugar chemistry, the great activity in this special field of work could not pass without leaving a deep impression on chemical philosophy. Indeed, it should be an easy matter to defend the thesis that every important industrial research extended over a long period of time must furnish a contribution to chemical philosophy which by generations to come will be adjudged to be of greater moment than the practical end which by its very nature can be of temporary value only. The history of chemistry furnishes many instances supporting this thesis, but it suffices to mention the trivial practical task which suggested to Dumas the theory of substitution.

With this thought in mind it may be proper to review briefly the contributions made by sugar chemistry to chemical theory.

The evolution of every science begins with the selection and assembly of material, the description and the analysis of which will constitute that special branch of science. It begins with a purely empirical phase which may be referred to as the period of discovery. To discover and to describe individual substances, separated from a mass of other substances, was the aim of the early chemists. It was then a purely intellectual pursuit. At this period the sugars were a great help and comfort to the chemist for the reason that many natural sugars possess great crystallizing powers. Indeed, cane sugar had been known for a long time in the Orient and was introduced to Europe by Alexander the Great. Milk sugar was crystallized in 1615 by an Italian chemist, Bartaletti, and in 1660 grape sugar was crystallized by Glauber. The important achievement of this period of chemical history was the announcement by the Russian chemist Lowitz in 1793 of the principle of crystallization as a method of purification. Another important achievement of the same period was the introduction of the microscope as a chemical instrument. The occasion for this was the analysis of beets for cane sugar. The incident led to the beet-sugar industry.

The period of discovery of natural substances was followed in the evolution of our science by the one that may be termed the period of discovery of derived substances. In this period the source of discovery was not a complex mixture of natural substances but a mixture derived artificially from a single natural substance. Again the chemist found in sugars suitable medium for these exploits for among the many decomposition products of sugars, some crystallized readily. Such substances were oxalic acid discovered by Bergmann and by Scheele, saccharic and mucic acids discovered by Scheele and many others. This purely intellectual pursuit then led to the discovery of substances which played an important part later when problems of structure came to the front.

As a rational and truly scientific discipline organic chemistry was recognized with the formulation of the ideas of chemical structure or of molecular architecture. To-day it is impossible to conceive of the term "chemical structure" without including in it that of "isomerism." Yet the idea that substances of the same composition might possess different properties was unacceptable even to Berzelius. But gradually the idea gained ground, being sponsored by the authority of Gay-Lussac, who called attention to the fact that sugar, gum and starch had similar compositions and different properties which, he maintained, were attributable to differences in the arrangements of the atoms in the individual components. True, the evidence of Gay-Lussac was not as good as his idea, but one must bear in mind that the concept "polymerism" was not yet known and that the analytical methods of Gay-Lussac were the best available. However, if it be permitted to classify tartaric acids among the sugar derivatives, then to sugar derivatives will belong the credit first for having suggested the idea of isomerism and second, for having brought about its general recognition. Indeed, it was after the discovery of mesotartaric acid by Gmelin that Berzelius withdrew his opposition to the idea that substances of identical composition might possess different properties, and indeed it was Berzelius who introduced the term "isomerism."

The term "polymerization" had a still longer struggle for recognition. But no sooner was it recognized than it was realized that simple sugars may be regarded as polymers of formaldehyde, and the Russian chemist Butlerow proceeded to demonstrate the truth of the assumption by condensing formaldehyde to a sugar. It must be added that the term "polymerization" even to-day embraces many diverse phenomena of which only some justly belong under that heading while others may be separated under the heading "condensation." The classification of these concepts and the unraveling of the nature of the forces which are responsible for the process of polymerization are some of the outstanding problems of chemical theory of to-day, particularly the phase bearing on the structure of the natural products of high molecular weight. The nature of these forces, which in a general way may be termed molecular in distinction to the primary-valence atomic forces, as yet is unknown. Their existence, however, nobody familiar with substances related to sugar, namely, α-hydroxy aldehydes, will ever doubt. For these substances remain in monomolecular state only for a brief space of time and pass spontaneously with the evolution of heat into a dimolecular, as if by this means liberating energy which subsequently may be utilized for the condensation of the simple substances into those more complex. Whether or not the complex substances such as starches, cellulose, gums, proteins, lignins, etc., are the products of molecular or of atomic forces is as yet not certain but the work on sugars now in progress in many laboratories is bound eventually to furnish the answer.

The most monumental contributions of sugar chemistry belong to the chapter on stereoisomerism. At the time Fischer began his researches on sugars, stereochemistry was a novelty looked upon with scepticism by many and was not tested experimentally from the view-point of predictions which the theory permitted. Fischer set out to test these predictions on sugars and verified the theory completely. Thus, sugar chemistry, more than any other branch of our science, helped to gain recognition for the

views of van't Hoff and Le Bel. In the hands of Hudson the sugars attained another triumph by furnishing evidence to the optical superposition theory of van't Hoff. This triumph is of special significance for the reason that it was based not on a qualitative but on a quantitative method, and a science enters the category of an exact science only when it is based on quantitative arguments.

The contributions of sugar chemistry to stereochemistry go beyond these points. The more intimate knowledge of the relationship between structure and optical activity will depend upon establishing configurational relationships between simple substances containing one asymmetric carbon atom. The early work in this direction was based upon the knowledge of the configurations of simple sugars and of the acids derived from them.

One of the very disturbing observations in the field of stereochemistry was made by P. Walden in 1893 when he found that the reaction of substitutes on an asymmetric carbon atom may be accompanied by a stereochemical inversion. The observation, since then known as the Walden Inversion, has intrigued many chemists, and again the sugars offered a valuable medium for the study of the phenomenon.

From all that has been said, an impression may be gained that for the evolution of chemical theory sugars played rather a modest rôle to test theories which came to the front through observations in other fields of chemistry. At least one case may be mentioned where the observations on sugars suggested a new thought, the one of the possibility of an asymmetry produced by a carbon atom combined with three other groups only. It was the observations on the ethyl ester of the diazogluconic acid which suggested the possibility of the existence of optically active aliphatic diazoesters.

Finally, it would be no exaggeration to state that the most recent phase of sugar chemistry holds out more promise of general significance than any of the preceding phases. It deals with the migration of groups in the partially substituted sugars and with the dynamic isomerization of ring structures.

Passing now from organic to bio-chemistry, we find that there also sugars contributed much to theory. The difficult and exhaustive work done by Nef on the dissociation of sugars had for its objective the explanation of the process of fermentation. The work of Evans aims at the same end. The problem of fermentation is one of the most important problems of general biology, not because of the commercial or medicinal value of alcohol, but because the process of utilization of sugars by higher and lower living forms in many respects resembles that of fermentation and because what is learned about one of these processes may help towards understanding the other. The mechanism of biological dissociation of sugar as it is seen to-day could not have been conceived without the preceding work on the chemistry of sugars. It is enough to mention the discovery of phosphoric esters of the sugars as an essential step in fermentation as well as in animal combustion of sugar.

Above all, sugars have contributed to our understanding of the most important biological agents, the enzymes, the agents which occupy the intermediate place between non-living and living matter. For it was sugar chemistry which removed much of the mystery of the nature of these agents and placed them in the category of simple chemical substances acting in solution. How else can one explain the stereospecificity of the enzymes? The deduction formulated by E. Fischer in regard to relationship between enzyme and substrate, when the substrate was a sugar, is now accepted in relation to practically all enzymes.

All the contributions of sugar chemistry to general chemical theory, however, were the result of the progress in the knowledge of the details in the structure of simple and complex sugars. It is therefore appropriate to enumerate briefly the landmarks in the history of sugar chemistry. I should like to begin the modern history of sugar chemistry with the name of Butlerow, who was the first to prepare a sugar from the simplest components—from formaldehyde. No really great progress was made after the days of this Russian chemist until Kiliani's synthesis of sugars. On the foundation of Kiliani's work and on the basis of van't Hoff's theory, Fischer erected the wonderful structure of the stereochemistry of sugars. Mention also should be made of Tollens' suggestion of the cyclic structure of glucosides. After Fischer's work was completed, it seemed as if human ingenuity had exhausted all the accessible knowledge in the field of sugar chemistry. But then two new methods came to the front, the result of which is the recent work in the field of sugar chemistry.

One of the methods is that of methylation first introduced by Purdie and made popular by Irvine and the second is the application to sugars of van't Hoff's optical superposition theory by Dr. Hudson. About his latest work on the ring structure of sugars you have heard from him personally, and the gathering here to-night is evidence of your appreciation of this work; but may I remind you of Dr. Hudson's earlier pioneer contributions—which are as serviceable to-day as they were on the dates of their discovery. They are:

The rational classification of alpha and beta forms of sugars and of glucosides. All sugar chemists still remember the arbitrary manner of the older classification and the chaotic state of nomenclature of the various forms of glucose and of other monosac-

charides. Hudson's rule then permitted him to elucidate the alpha and beta structure of di- and trisaccharides, a problem which previously could be solved only with much difficulty.

Then came the rule correlating the structure of lactones with their optical properties. This rule subsequently played an important part in determining the ring structure of glucosides.

Then came the amide rule of rotation which permitted the correlation of the structure of hydroxyacids and sugar acids, and as by-products of his theoretical work are many discoveries of new forms of isomerisms and of rearrangements.

It is a rare occurrence that a single principle has led to so many discoveries. All sugar chemists of to-day have been assisted in their work on more than one occasion by the rules which are known as Hudson's rules.

MICHAEL FARADAY. II[1]

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In the fall of 1831 Faraday began the first section of his great work, "Experimental Researches in Electricity," the work which he continued for some twenty-three years. These researches appear from time to time as papers transmitted to the Royal Society and they were subsequently put together in a single set of three volumes. They give a most detailed description of his thoughts and work. Experiments are described in the minutest detail. Every paragraph is numbered consecutively from beginning to end, and cross references are added to serve as connecting links between the various researches. His first experiments are on the induction of electric currents. Following the general notions evolving from the known facts that charged bodies induce electrical charges in others in their vicinity, he inquires whether any such phenomena can occur in the case of electric currents. Such problems as these present themselves to him. Suppose we have a wire in which a current is flowing, do we alter in any way the magnitude of that current by bringing into its vicinity another wire carrying a current? The kind of effect he is looking for is one where there will be some permanent alteration or at least an alteration which will persist for the whole of the time that current No. 2 is brought into the vicinity of current No. 1. He makes tests in all sorts of different ways and is finally led to the now well-known result that the induced current occurs only at the moment of change of the other current or during the periods of motion of the circuit carrying that current. Nevertheless, the nature of these phenomena is such as to cause his mind to lay hold of the idea that the various circuits which are involved are not actually ignorant of each other's presence. He thinks of them as being conscious of that presence in sort of a silent way. He thinks of them as being in what he calls an electrotonic state. His mind lays hold of the thought that it is in the change of that state that the current manifests itself. In order to appreciate the whole significance of his attitude in this matter, we must transport ourselves to a state of mind where we do not have the pictures of lines of force which we enjoy to-day. All that came later as an extension by Faraday himself of the ideas which he formulated in the early history of the subject. We have before us simply a set of wires all apparently unconscious of each other's presence. Yet any one of them has the power to know if any change is made in the other. It is one of the characteristic features of Faraday's way of thinking that he seemed to have the faculty of arriving at the essential elements which matter in a qualitative form long before he was able to place that exact significance to them which is associated with quantitative relationships. The quantity which was associated with the electrotonic state appeared in the hands of Clerk Maxwell as the electromagnetic momentum associated with the circuit. Or in terms of more intuitive concepts it refers to the product of the current and the total flux of magnetic induction through the circuit. It is this quantity, a purely mathematical quantity having no physical significance in the ordinary sense of the word, which Faraday succeeded in ferreting out of his experiments as the quantity essential for the coordination of his results. Speaking of this electrotonic state, as visualized by Faraday, the great Clerk Maxwell writes:

> By a course of experiment, guided by intense application of thought, but without the aid of mathematical calculations, he (Faraday) was led to recognize the existence of something which we now know to be a mathematical quantity, and which may even be called the fundamental quantity in the theory of electromagnetism. But as he was led up to this conception by a purely experimental path, he ascribed to it a physical existence, and supposed it to be a peculiar condition of matter, though he was ready to abandon this theory as soon as he could explain the phenomena by any more familiar forms of thought. Other investigators were

[1] An address given on February 14, 1931, at the Massachusetts Institute of Technology, under the auspices of the Department of English and History.

long afterwards led up to the same idea by a purely mathematical path, but so far as I know, none of them recognized, in the refined mathematical idea of the potential of two circuits, Faraday's bold hypothesis of an electrotonic state. Those, therefore, who have approached their subject by the way pointed out by these eminent investigators who first reduced its laws to a mathematical form have sometimes found it difficult to appreciate the scientific accuracy of the statements of laws which Faraday, in the first two series of his "Researches" has given with such wonderful completeness.

The scientific value of Faraday's conception of an electrotonic state consists in its directing the mind to lay hold of a certain quantity, on the changes of which the actual phenomena depend. In spite of the fact that the experimental researches of Faraday do not contain a single line of mathematics, Maxwell refers to him as one of almost unrivaled mathematical insight. Speaking in another place he remarks:

> It was perhaps for the advantage of science that Faraday, though conscious of the fundamental forms of space, time and force, was not a professed mathematician. He was not tempted to enter into the many interesting researches in pure mathematics which his discoveries would have suggested if they had been exhibited in a mathematical form, and he did not feel called upon either to force his results into a shape acceptable to the mathematical taste of the time, or to express them in a form which mathematicians might attack. He was thus left at leisure to do his proper work, to coordinate his ideas with his facts, and to express them in natural, untechnical language.

A guiding principle which we find operative again and again in Faraday's activities is his belief in the unity of nature, the belief that the various phenomena which manifest themselves in different ways through magnetism or electrically, etc., are all fundamentally of the same kind. Indeed in these researches on the induction current, he speaks of the evolution of electricity from magnetism.

It had been observed by Arago that if a plate of copper be revolved close to a magnet needle suspended in such a way that the latter could rotate in the plane parallel to that of the former, the magnet tended to follow the motion of the plate. Faraday proceeds to discuss this phenomenon and to develop the theory of its action. Then he sets up an experiment in which he revolves a copper disc between the poles of a magnet and makes contact between the edge and the center to a galvanometer. A continuous current is produced, and the first dynamo is in operation. He then applies these ideas to the induction of current in the earth as a result of its rotation in its magnetic field, and draws interesting conclusions concerning the effects upon terrestrial magnetism. He makes experiments upon earth currents on the Thames, and obtains the permission of the king to make experiments at the lake in the garden at Kensington Palace.

At the present time, when our views as to the significance of an electric current have become so concrete, it is well to remind ourselves that in the early stages of the sciences it was by no means obvious that those things which we now call electric currents were of the same character regardless of their mode of production. The realization of a current of electricity from electrostatic charges, from a voltaic cell, and from electromagnetic induction, involves such a diversity of methods in the production of the phenomena that, in the early history of the subject, the question of the identity of electric currents produced by different means was one whose solution was by no means obvious. The importance of a solution to the problem was very evident to Faraday. "It was essential for the further presentation of my inquiries," he writes, "that no doubt should remain of the identity or distinction of the electricity excited by different means." Then by a series of carefully planned experiments he proceeded to test this all-important question and to reach the solution that the apparent differences, striking as they may be as regards the method of production of the current, have no effect whatever upon the nature of the current itself. The high spot in his demonstration of the similarity of different kinds of current was attained in his showing that all of them were able to produce decomposition of certain chemical compounds into their element. These researches led him into a careful examination of the subject which we now know as electrolysis.

That the chemical substances could be broken up by the agency of an electric current was well known, but the mechanism of the process was in a very unsatisfactory state. It was generally assumed that the conductors by which the current entered and left the solution produced an electric field which had the power of tearing the atoms asunder. Faraday realized that such a procedure was entirely inadequate to account for the facts; for, apart from all other considerations, on such a view, it would follow that the slightest electrical tension would be more powerful than the strongest bonds of chemical affinity, since the slightest current would cause chemical decomposition. By an elaborate series of experiments attacking the matter from all sorts of points of view, he finally established the conclusion that the rate of chemical decomposition in any given substance is absolutely independent of all consideration other than the current which passed through it. It matters not whether the electrodes are small or large or even whether there be any electrodes at all. The current alone was the quantity which played the vital part. And so Fara-

day established his well-known First Law of Electrolysis; and his celebrated voltameter, whose action rests upon the definite proportionality between rates of chemical decomposition and current, served for many years as the only practicable method by which quantities of electricity could be accurately measured. In connection with these various researches he came to the establishment of certain well-known terms which exist in the literature of the subject to-day. The wires by which the current entered and left the substance which was being decomposed he termed the electrodes, and the substance which was deposited upon those electrodes he called "ions" or "wanderers." The substances which went to these electrodes he called, respectively, anions and kations. One of the electrodes he called the anode and the other the kathode. To the decomposition itself he gave the name electrolysis and substances which were capable of being disintegrated by the electric current he termed electrolytes. It is a characteristic feature of Faraday's mental process that, while he thought of the working entities of nature in a most realistic way, having formulated his concepts, he sought to remove from them as many irrelevant appendages as were unnecessary for the performance of their desired functions. The very term of electricity itself was somewhat distasteful to him as implying a type of mechanism which was not necessarily a unique representative of the experimental facts. Continuing his study of the decomposition by the electric current, he finally came to the formulation of his second law of electrolysis which states that if the same current be passed through different electrolytes in series, the weights of the different substances deposited in a given time are proportional to the chemical equivalent of the substances.

He next takes up the question of the origin of the electromotive force in the voltaic pile, which, it will be recalled, consists of an alternating series of the following kind. First, we have a copper disc, then a piece of blotting paper soaked in a solution, then a zinc disc, then another copper disc, then another piece of paper and so on. It had been customary to suppose that the seat of power in this pile lay in the contact of the metal surfaces, and such a theory was supported by many eminent philosophers. Faraday had become imbued with the conviction that the production of the electric current was associated with chemical decomposition. His experiments on electrolysis showed that the current passing through an electrolyte caused such decomposition, and in the mechanism of the voltaic cell itself he saw a similar phenomenon taking place, the only difference being that here the chemical action took place in the reverse manner.

> The contact theory [he urged] assumes that a force which is able to overcome powerful resistance, as for instance that of the conductors, good or bad, through which the current passes, and that again of the electrolytic action where bodies are decomposed by it, can arise out of nothing: that without any change in the acting matter, or the consumption of any generating force, a current shall be produced which shall go on forever against a constant resistance or only be stopped as in the voltaic trough, by the ruins which its exertion has heaped up in its own course. This would indeed be a creation of power, and is like no other force in nature. We have many processes by which the form of the power may be so changed that an apparent conversion of one into the other takes place. So we can change chemical force into the electric current, or the current into chemical force. The beautiful experiments of Seebeck and Peltier show the convertibility of heat and electricity; and others by Oersted and myself show the convertibility of electricity and magnetism. But in no case, not even in those of the Gymnopodous and Torpedo, is there a pure creation or a production of power without a corresponding exhaustion of something to supply it.

Here in this statement, made before the time when Meyer had published his "Essay on the Forces of Inorganic Nature," and before Joule had performed his experiments upon the mechanic equivalent of heat, we have a foreshadowing by Faraday of the principle of the conservation of energy.

These investigations in electrolysis and the like occupied him until the end of the year 1834, when his attention was directed to the whole question of electrostatic induction. The poles of the voltaic battery had suffered a great loss of prestige in his hands. He seems to see in them nothing but flag poles announcing what is going on in the medium between them, and so he becomes suspicious of the whole idea of electric charges on conductors acting upon each other through the intervening medium. He sees that a so-called charged body can induce a charge on another one which is screened from it in the optical sense, *i.e.*, in the sense that one body would be invisible from the other. The effect attributed to the body A has a mysterious property of being able to travel around the corner and visit body B. And so he comes to concentrate his mind more upon the medium itself than upon the so-called charges on the various bodies. The body is to him merely the means by which the action of the medium is supposed to become apparent. Moreover, the charge distribution produced on the body B by the presence of a charged body A is altered by changing the nature of the medium between the two, as, for example, by the interposition of a sphere of wax. Thus action at a distance has to take some cognizance of the medium

between. He sees the medium as a seat of some kind of strain associated with his lines of force. A dielectric is a substance which is capable of sustaining the electrical strains, while a conductor is one which for reasons at the time unknown was unable to withstand it and yielding to it gives rise to an electric current. Hence these lines of electric force end abruptly when they fall upon a conductor. The electric charges (and Faraday dislikes the very word charge) which appear on the conductors are thus only the termination of these lines of force, one end of the line being positive and the other end negative. Like stretched cords these lines tend to contract while they exert also a lateral repulsion against each other which holds them in equilibrium. It was not until a much later date that Maxwell represented in elegant mathematical form this concept of Faraday, and actually found the magnitudes of the pressure and tension which it was necessary to associate with the medium in order that the lines of force as Faraday conceived should hold themselves in equilibrium. When one reads through Faraday's experimental researches and finds in them no mathematical formula, one sometimes wonders whether a person of his intuitive powers of conception may not, as a result, have limited his vision as to the generality of the possibilities. The more closely we read, however, the more we see that even when delving in those realms which are the natural field of mathematical analysis, he has an uncanny way of knowing exactly what he is doing. His concepts developed in terms of lines of force grew stronger and stronger during the whole of his life of investigation; and, yet, he was fully aware of the fact that in spite of the great reality with which the lines stood out to him in his thought, they were only one way of viewing the phenomena, but a way which he regarded as particularly efficient for the purposes of those phenomena. Writing at a much later date he says, speaking of magnetic lines of force, although the arguments are the same:

> Now it appears to me that these lines may be employed with great advantage to represent the nature, condition, direction and comparative amount of the magnetic forces; and that in many cases they have, to the physical reasoner at least, a superiority over that method which represents the forces as concentrated in centres of action, such as the poles of magnets or needles; or some other methods, as, for instance, that which considers north or south magnetisms as fluids diffused over the ends or amongst the particles of a bar. No doubt, any of these methods which does not assume too much, will, with a faithful application, give true results; and so they all ought to give the same results as far as they can respectively be applied. But some may, by their very nature, be applicable to a far greater extent, and give far more varied results, than others. For just as either geometry or analysis may be employed to solve correctly a particular problem, though one has far more power and capability, generally speaking, than the other; or just as either the idea of the reflection of images, or that of the reverberation of sounds may be used to represent certain physical forces and conditions; so may the idea of the attractions and repulsions of centres, or that of the disposition of magnetic fluids, or that of lines of force, be applied in the consideration of magnetic phenomena. It is the occasional and more frequent use of the latter which I wish at present to advocate.

The researches on electricity and magnetism so far reviewed occupied Faraday for a period of about ten years. A few personal incidents of this period are of interest. Sir Robert Peel, with the idea of rewarding and encouraging science and literature, had instituted the system of the Royal Pension to be granted to men of distinction, the grants being made in such a form as to render them acceptable without the appearance of receiving charity. One of these pensions was intended for Faraday, but Sir Robert Peel was out of office before the matter matured in his case, and it fell to the lot of the new prime minister, Lord Melbourne, to invite Faraday to an interview upon the subject. His lordship was evidently not sympathetic with the whole proposal and evidently conveyed his impression during the conversation. It is said that he referred to this giving of pensions to scientific and literary men as so much "humbug," and it is even said that he qualified the word humbug with an epithet which Faraday described as "theological." Faraday's dignity was hurt and he brought the interview to a close. A few hours later, he called upon the prime minister, and left his card with a note, "Declining to accept at your Lordship's hand that which through it has the form of approbation, is of the character which your Lordship so pithily applied to it." Lord Melbourne seems to have treated the matter at first as a joke, but being made conscious of its seriousness by friends who had a greater appreciation of Faraday's work than he had, and being, moreover, apparently a good-natured kind of soul, he became anxious to put the matter through in spite of all. However, Faraday would have nothing to do with the pension until the offensive word had been withdrawn and apologized for. It is a happy reflection upon the character of Lord Melbourne that he saw a greater salvage of the dignity of England's prime minister in honorable retraction of the offensive words than in resting dignity upon the false pride of office, and leaving a shadow which in later years could only have filled with chagrin the hearts of those who respected him.

The strain of the years of activity upon which Faraday had spent his energy up to the end of the first period of his electrical researches had resulted

in repeated attacks of bad health, the attacks taking the form of headaches, dizziness and occasional loss of memory. He would be apt to forget some of the experiments that he himself had performed and was unable to make use of his own investigations for the purpose of further advance. At the beginning of 1841 the trouble became so pronounced that he was advised to take a complete rest; and, for a year his work at the Royal Institution was interrupted. His rest took the form of a trip abroad in which as usual he gives a most detailed account of what he did and saw. The beauties of nature are a never-ending source of delight to him, and finally he and his wife returned to England at the end of the year, his health much improved, although it is doubtful if he ever completely recovered from his breakdown.

The second period of his researches occupied the years from 1845 to 1855. Faraday was endowed with an overwhelming conviction concerning the unity of nature, and he was continually trying to see relationships between different parts of science which at first seemed disconnected. The first paper of his second series of experimental researches in electricity dealt with the rotation of the polarization of light in a magnetic field. It has a rather curious title "The Magnetization of Light and the Illumination of Magnetic Lines of Force," a title which gave rise to some misunderstanding as to its significance. The paper starts with the sentence:

> I have long held an opinion, almost amounting to conviction, in common I believe, with many other lovers of natural knowledge, that the various forms under which the forces of matter are made manifest have one common origin; or, in other words, are so directly related and mutually dependent that they are convertible, as it were, one into another, and possess equivalents of power in their action. In modern times the proofs of their convertibility have been accumulated to a very considerable extent, and a commencement made of the determination of their equivalent forces.

In a later paper he proceeds to test a possible relation between gravity and electricity, endeavoring to obtain electric currents by moving coils in the earth's gravitational field in all sorts of different ways. These experiments bear no fruit, but he nevertheless ends the description of them with the statement, "Here end my trials for the present; the results are negative but they do not shake my strong feeling of the existence of a relation between gravity and electricity, though they give no proof that such a relation exists." To this period of Faraday's activities belongs his discovery of the magnetic characteristics of materials. The words "paramagnetic" and "diamagnetic" are introduced by him, and he makes an exhaustive examination of these phenomena in all sorts of different substances including gases. He is particularly interested in the paramagnetic characteristic of oxygen, and thinks that he sees in it, when combined with the temperature variations, an explanation of the variations of terrestrial magnetism. Then we have a long discourse on lines of magnetic force within and without a magnet, and the citation of many of those experiments on unipolar reduction which have occurred so frequently in discussion in the literature, up to the present time. An experiment cited by Faraday is one in which a cylindrical magnet is mounted so that it can revolve about its axis. A wire is joined from one pole of the magnet to the equatorial belt of the magnet through a galvanometer. It is experimentally found that on rotating the magnet and wire together no current is observed in the galvanometer. On the other hand, if either the magnet or the wire be rotated separately a current is produced. The explanation of these effects is one which has puzzled a great many people. In fact, physicists divide themselves into two classes. First we have those who are familiar with the mathematical theory, and to them everything is perfectly clear in the sense that it is all explained by the equations. Then there are those who think intuitively in terms of lines of thought, and in whom a large part of their knowledge of the subject is bound up in the statement that when lines of force cut across a conductor either by the motion of the field or by the motion of the conductor, an electromotive force is produced which is proportional to the rate of cutting off the line. Arguing on this basis, they find a great deal of difficulty in understanding the experiment. They are apt to think of those lines of force of the magnet visualized in the shape of material threads attached to the magnet, so that when the magnet is rotated, these lines partake of the rotation. Such a state of affairs leads to erroneous conclusions as regards the currents excited. The mathematical theory leads to the conclusion that any interpretation which is to be made in terms of the cutting of lines of force must be one in which the lines of force of the magnet do not participate in the rotation. On the other hand, if one takes the magnet as a whole and moves it without rotation in the vicinity of a wire circuit, the electromotive force is accurately calculable in terms of the rate of cutting of the lines, where those lines are considered as carried along with the magnet in its motion. It is an astonishing thing that a large number of physicists who are keen in their judgment but do not happen to have the mathematical technique at hand find the greatest difficulty in getting the right point of view in this matter. Nevertheless, Faraday, who was in this group in the sense that he did not have the mathematical technique wherewith to handle the equa-

tions, and in fact the equations did not exist at that date, had formed a perfectly definite conception of the attitude which must be adopted toward lines of force and their motion in order that the conclusion to be expected should agree with the facts. Thus he writes:

> When lines of force are spoken of as crossing a conducting circuit they must be considered as effected only by the translation of a magnet. No mere rotation of a bar magnet on its axis produces induction effects on circuits exterior to it; for then, the conditions above described are not fulfilled. The system of power about the magnet must not be considered as necessarily revolving with the magnet, any more than the rays of light which emanate from the sun are supposed to revolve with the sun. The magnet may even in certain cases be considered as revolving amongst its own forces, and producing a full electric effect, sensible at the galvanometer.

This statement shows that Faraday had no difficulty at all in adjusting his mental attitude so that a motion of lines of force along with the magnet when in translatory motion was in every way consistent with a view which considered them as stationary in respect to the rotation of the magnet. If one tries to visualize these lines too completely, there is a danger of an inconsistency arising between these two view-points. How is it possible, one may say, that the magnet can rotate without its line going around with it like a squirrel cage? It is an example of the peculiar power of Faraday's reason that he was able to see just how far he could materialize the association of these lines with the magnet so as to give him the maximum of mental satisfaction without forcing into them a spurious concept of reality in relation to their attachment to this magnet which would have been contradictory to the facts. Another example of his power to make physical intuition his servant rather than his master is found in his supposing that in the case of a bar magnet, for example, the lines of force pass continuously around the outside of the magnet through the magnet itself, so that in the substance of the magnet they travel in the opposite direction to the field one would think of there, if he pictured to himself the magnet simply as a pair of poles. In spite of the fact that this property of magnetic lines of force, or rather lines of induction, as we have come to call them in this case, is insisted upon in all the text-books, I wonder if there are many students in the unsophisticated stage who really understand what is meant. If one tries to think of the phenomena in terms of a magnet made up out of smaller magnets, each with a pair of poles, the magnetic induction within the substance assumes the form of a mathematical vector to which there is no direct physical significance in the sense in which one pictures the actual forces between the various elementary poles of which the little magnet is composed. Even if the elementary magnets be replaced by amperian current whirls or by rotating electrons, the actual field within the interstices of the atoms assumes a highly complex form, and it is only in the sense of an average quantity that this vector, the magnetic induction within the substance, assumes a concrete form. However, it is a quantity which is certainly definite in the same sense that the average magnetic energy of a whole lot of molecules is a perfectly definite thing, a thing in fact directly associated with the temperature of the substance; and, to Faraday, the quantity became concrete as soon as it was possible to define it in terms of its properties. He early seized upon the fundamental characteristics of these lines of force or induction, the characteristic which provides for what in the mathematical theory is called the solenoidal condition, the characteristic which provides for the fact that the total flux of lines through any closed surface is equal to zero, so that the outward flux through one portion of the surface is equal to the total inward flux through all the other portions. In speaking of this matter he speaks with a conviction which goes even beyond the mere experimental requirements that a conclusion must be true. For he says:

> I regard the destruction of force, and still more emphatically of one form only of a dual force, is as impossible as the destruction of matter. All that is permitted under the general laws of nature is a displacement of the force and these conditions are as true of the smallest suppressions of force or part of a force as of the suppression of the whole.

His picture of electromagnetic phenomena becomes painted entirely in terms of these tubes of force. It is in terms of the rate of change of flux through a surface that he ultimately expresses the story of the induced current therein; and so through the agency of these tubes of force he realizes what is now to him the physical significance of that quantity which in his early researches he associated with what he called the electrotonic state, the quantity which in the hands of Maxwell figured as the electromagnetic momentum of the circuit concerned. The concept of polarity becomes repugnant to him in electrostatics and in magnetism, as it had become repugnant to him in the theory of the voltaic cell. He raises the question, "What is magnetic polarity and how is it to be defined?" He goes on to say, "For my own part, I should understand the term to mean the opposite and antithetical actions which are manifested at the opposite ends or the opposite sides of a limited, for instance, or unlimited, portion of a line force." Later he says, "If the term polarity has any meaning which has reference to experimental facts and not to hypothesis which is not included in the above description, I

am not aware that it has ever been distinctly and clearly expressed."

In all these researches of Faraday, one has to remember that he was working in a time when one did not think in quantitative terms, as we do to-day. There was no ohm, no ampere and the like in terms of which to talk. When he speaks of measurements he talks in such terms as: "the voltaic current which I used upon this occasion was that of five pair of grove cells. The electromagnets were of such power that the poles would seem to sustain a weight of from twenty-eight to fifty-six or more pounds." Then again when citing experiments on the effects of different quantities of charge he talks of the number of rotations which he makes in the wheel of his electrical machine. On the other hand, in these experimental situations, just as in his theoretical discussion, he shows an intuition so well described by one who said, "He smells the truth." In using the crude galvanometers of the day to investigate some of the phenomena of induction, he comes to the conclusion that it is better for the purpose in hand to use an instrument with one turn in its coil than to use one with many. For he says, "Such a wire had abundant conducting power; and though it passed but once around each needle, gave a reflection many times greater than that belonging to the former galvanometer." Again when he is obtaining current from a battery of cells he finds that it is better to join them up in a combination of what we call series and parallel, than to adopt either of these methods exclusively. The only place where he gives a suspicion of failing in a minor way to recognize the full significance of the elements involved is where, on making a simple arithmetical calculation concerned with measurements which are necessarily rough and semi-qualitative in nature, he expresses his calculations and results to seven significant figures.

Some of his last work concerns meditations on the nature of light which he tried to visualize simply as undulations of his line of force; and, while he did not carry the development of this matter very far, it is significant that here also he "smells the truth"; for, as so vividly portrayed in the calculations of radiations, we see the essential element of the electromagnetic waves, from a charged particle in motion, for example, as resulting from a super-position of ripples upon the lines of force of the charge in such a manner as to leave intact the permanence of those lines of force as regards the constancy of their flux through a closed surface surrounding the charge.

And so we come to the close of the career of this great prince of experimentalists whose labors fired the spark which has illuminated the whole realm of modern physics. As age crept on, his forgetfulness increased more and more. His last lecture was delivered in 1862, and the same year saw his last experiment. As he felt his powers weaken he laid aside his duties one by one. He was invited to assume the presidency of the Royal Society but declined. It was inevitable that the managers of the Royal Institution should feel it fitting that, as his career drew to a close, he should be asked to be president of the institution to which he had brought such lasting fame. But he felt that the duties of this position, if conscientiously performed, would be beyond his powers at the time, and he was not one to take the task and, in carrying it through, fall below the standard set by his very high ideals. The closing years of his life were spent near Hampton Court in a house placed at his disposal by the Queen in 1858; and it is a comforting thought that in spite of the weakening of his powers time treated him kindly as regards his general health. He suffered from no disease, and his end came without pain on the 25th of August, 1862, while seated in a chair at his desk.

OBITUARY

NORIFUMI OKAMOTO

ON February 17, 1931, Japan lost one of the foremost scholars in the field of the history of her native mathematics, Mr. Norifumi Okamoto. In the oriental countries it is not enough that such a man should be well versed in mathematics as a science; for this he may be without the ability to read with any ease the works of the classical writers of his own language. This is due to the fact that modern mathematics makes use of terms and methods unknown to ancient writers, whereas the terminology used by the latter is like medieval Latin words to a modern student of analysis. In the person of Mr. Okamoto both necessary elements for the interpretation of the classics were combined, for in his youth, before the Restoration, he was taught the mathematics of the past, and after the abolition of the shogunate he took up the study of the occidental works in the same field. He was one of a band of young and enthusiastic teachers to make the first Japanese translations or adaptations of European text-books and thus to bring into the modern schools of his country the ideas of the western world.

When the Japanese government decided to establish normal schools as part of its modernizing program he was appointed the principal of one of these institutions, and when the Peers' College was founded it was to him that the authorities turned for advice,

and it was he who became the first head master. In later years he taught in the Military Officers' School at Tokyo, and was for a time the superintendent of the Seijo Gakko, or Middle School. During all these years he devoted a great deal of time to the study of the mathematical classics, fitting himself to become a worthy successor to Mr. Endō, whose work on the history of Japanese mathematics is deserving of being ranked as itself a classic. He was also much interested in the subject of geometric transformations as treated by Ushijima Seiyo and Hodoji Zen and had planned to publish a work upon the subject, a project that he did not live to carry out.

For some years before his death he was engaged in preparing a catalogue of the large collection of early Japanese mathematical manuscripts and printed books in the Imperial Academy at Tokyo, a line of work for which he was admirably fitted.

In manner he was a "gentleman of the old school," kindly and yet reserved. He wrote but little, always hesitating to put on paper that which he felt to be in need of further perfecting. Perhaps it was as well that this was the case, since it left him more time for work upon the library, a task which was left unfinished but which was complete as far as he went.

I am indebted to friends in Japan for much of the above information concerning Mr. Okamoto's life, and to my own impressions of him formed on a visit to the library only a year ago. If Japan should induce Mr. Mikami to carry on the labors of his friend, this would be looked upon by western scholars as fortunate for the development of the history of the native mathematics of that country.

David Eugene Smith

Teachers College,
Columbia University

MEMORIALS

Dr. George H. Bigelow, commissioner of health of Massachusetts, will deliver the sixth Hermann M. Biggs Memorial Lecture, May 7, at the New York Academy of Medicine. The subject of the lecture will be "Will Physicians Practice Preventive Medicine?" The lectureship, founded by the widow of Dr. Biggs, was until this year administered by the New York Tuberculosis and Health Association and the Medical Society of the County of New York. Previous lectures were given by Dr. William H. Park, 1925; Dr. S. Lyle Cummins, Cardiff, Wales, 1926; Dr. Allen K. Krause, 1927; Dr. Charles-Edward A. Winslow, 1928, and Dr. John H. Stokes, 1929.

The issue of *Wiener medizinische Wochenschrift* for March 14 is dedicated to the memory of Professor von Basch, the father of clinical sphygmomanometry, who died in 1905.

It is planned under the auspices of the academy at Béarn to erect a monument at Pau to Charles Moureu, the organic chemist who died on June 13, 1929, in memory of his services to science. The monument will be executed by the sculptor E. Gabard. Busts will be placed in the Collège de France and the Faculté de Pharmacie in Paris.

RECENT DEATHS

Professor Francis X. Dercum, from 1892 to 1925 professor of nervous and mental diseases at Jefferson Medical College, Philadelphia, since 1925 professor emeritus, died suddenly on April 23 while presiding at the business session of the annual meeting of the American Philosophical Society, which he had served as president for seven years. Dr. Dercum was seventy-four years old.

The death is announced of Dr. George Martin Kober, professor of hygiene and dean of the School of Medicine of Georgetown University until his retirement as dean emeritus in 1928, on April 24. Dr. Kober was eighty-one years of age.

Dr. John A. Foote, pediatrist and dean of the Georgetown University Medical School, with which he had been connected twenty-five years, died on April 11, at the age of fifty-seven years.

Professor Arthur J. Wood, head of the department of mechanical engineering at Pennsylvania State College, died on April 18 from injuries he received when he was struck by a motorcycle. Professor Wood was past president of the American Society of Refrigerating Engineers, former associate editor of *The Railroad Gazette,* and until 1918 associate editor of *Railroad Mechanical Engineering.*

Edgar Boyd Kay, formerly dean of the School of Engineering of the University of Alabama and chief of the hydraulic and sanitary division, quartermaster's office, United States Army, has died, at the age of seventy-one years.

The death is reported by *The British Medical Journal* of Dr. Jean Baptiste Coppez, professor of ophthalmology at Brussels from 1891 to 1905, aged ninety years; Dr. Auguste Slosse, professor of physiological chemistry at Brussels; Dr. Paul Frangenheim, professor of surgery at Cologne and an authority on bone surgery, aged fifty-four years; Dr. Giulio Tuno, a physiologist of Rome, and Professor Vogt, a Moscow pathologist, aged eighty-three years.

The death is announced of Dr. Hermann Matthes, professor of pharmaceutical chemistry in the University of Königsberg, and of Dr. Wilhelm Semmler, professor of chemistry at the University of Breslau.

SCIENTIFIC EVENTS

THE ZOOLOGICAL SOCIETY OF LONDON

THE annual report of the Zoological Society of London was recently issued. According to a summary printed in the London *Times* the assets amount to £178,202, an increase of £6,630 on the amount of last year, and the liabilities decreased by £1,064. Owing to the nature of the tenure of the ground occupied in Regent's Park the value of the buildings there can not be included in the assets, but, as the new estate of the society at Whipsnade is freehold, it is beginning to be a substantial asset. The income from fellows' subscriptions exceeded that of last year by about £1,000 and from gate-money also by over £1,000.

The report states that the experiment of opening the gardens on Thursday evenings, from June to September inclusive, begun last year, is to be continued this year, but a charge of 6d. is to be made for the aquarium, which was usually inconveniently crowded last year. Over 60,000 visitors entered the gardens on Thursday evenings after the usual time for closing the day admissions, and the council believe that the evening openings allowed many persons occupied during the day to visit the collection. As a strictly financial enterprise, however, the evening openings do little more than pay their way.

The pathologist reported that there were no serious epidemics among the animals, and that there had been a reduction in the mortality among mammals, birds, reptiles and amphibians. The following mammals were bred and reared: One pig-tailed monkey, one lemur, four galago lemurs, three lion-cubs, two pampas cats, one wolf, one sea-lion, two pygmy hippopotamuses, one Grévy's zebra, one kiang and one Mongolian wild horse, a water buck, two nylghaie antelopes, three black buck, one gazelle, one Wapiti deer, two Pudu deer, one reindeer, one Hangul deer, two American bison, two anoas, one yak, one Cape buffalo, one ibex, one Grecian wild goat, three Caucasian wild goats, nine Barbary sheep, nine moufflon, four thars, a Canadian beaver, a prairie marmot, three agoutis, a fruit-bat, two wallabies and two opossums.

The report announces that Whipsnade Zoological Park, although there will be many years before it is complete, will be opened to the public on Friday, May 22. On that day there is to be a "private view" for fellows and official guests, and from the following Saturday onwards it is to be open daily, including Sundays, to the general public from 10 a. m. until "lighting-up time." There are fully licensed premises for meals in the park and a car-park has been made ready opposite the only entrance yet available, about a quarter of a mile from the village of Whipsnade. Charabanc services are being arranged from the railway stations at Luton, St. Albans and Tring, as well as from London and centers in the Midlands.

The retiring members of council are Lord Alastair Innes-Ker, Professor J. P. Hill, Lord Onslow, Major Pam and Lord Rothschild. Those recommended to fill the vacancies are Sir John Bland-Sutton, Mr. H. G. Maurice, Sir Henry McMahon and Mr. E. G. B. Meade-Waldo, who have served on former occasions, and Sir Peter Clutterbuck, a Fellow who has not served before.

THE AMERICAN ASSOCIATION OF MUSEUMS

THE annual meeting of the American Association of Museums will be held at Pittsburgh on May 21, 22 and 23, according to *Museum News*. General and group sessions are designed for delegates from museums of all kinds throughout the country. A general session each morning will be devoted to a topic of equal interest to museums of art, science, history and industry. Each afternoon session will be given over to a single paper introductory to inspection of one of the host museums or of some other branch of the Carnegie Institute. On two evenings six groups will hold separate sessions. At these group sessions more specialized topics will be considered, but in the aggregate a wide variety of subject matter will be covered. The groups are the technical section, the scientific section, the superintendents' section, the art group, the educational group, and the public relations group.

Important features of the meeting will be the twenty-fifth anniversary dinner on the third evening, and the exhibit of the technical section. The exhibit will be open for inspection throughout the meeting.

The delegates will be entertained at luncheon each noon and at tea each afternoon. Also a trip has been arranged for Sunday morning to the Allegheny Country Club, with luncheon on the lawn of the club.

The general session of the first morning will take up branch museums with papers on the different kinds of branches already to be found and general treatment of the needs and future. The second morning session will be on international outlooks with presentations from the European and the American standpoint and a critical comparison of views. The third general session, on the last morning, will take up outdoor education from the standpoints of science, history and art museums. At this session also there will be a single paper and discussion on a particular field—that of industrial museum exhibits.

Proposals for participation in the technical section exhibit are being received by Remi M. Santens, Carnegie Museum, Pittsburgh, vice-chairman of the sec-

tion. The exhibit will include models, miniature groups, manikins, photographs, drawings, paintings, case displays and designs. All members of the section who desire to submit objects for display should communicate with Mr. Santens.

DECREASE IN THE NUMBER OF SCHOOLS OF MEDICINE

MORE than 800 American medical students attempted to enter a single medical school in Scotland during 1930. This is brought out by Dr. Willard C. Rappleye in a chapter on medical education in the Biennial Survey of Education in the United States, 1928–30, issued by the office of education.

Medical study in America is becoming more popular year after year, although the number of institutions offering medicine is decreasing. Five thousand more medical-school applicants were reported in 1929–30 than in 1926–27. Last year 66 approved four-year schools graduated as many physicians as were graduated by twice as many schools 20 years ago.

Of nearly 4,500 graduates in 1929, more than half were from 24 to 27 years old. Nine were 21 years of age, and 89 were 35 years or older. The typical medical school graduate in this country is 25 years old. He completes a four-year course, and generally supplements his medical school training with a one-year interneship in an approved hospital before going into practice. A one-year interneship or some other acceptable work of the same nature is now required before a medical degree is granted by Pennsylvania, New Jersey, Alaska, Rhode Island, North Dakota, Washington, Michigan, Illinois, Delaware, Iowa, South Dakota, Utah, Wisconsin and the District of Columbia.

With one doctor to every 800 persons the United States has more physicians than any other representative country. In other countries the number of people to one medical doctor is: Switzerland, 1,250; Denmark, 1,430; England and Wales, 1,490; Germany, 1,560; France, 1,690; the Netherlands, 1,820; and Sweden, 2,860.

Curiously enough, of the seventy-eight medical schools in the United States the one having the largest enrolment is the University of St. Thomas, Faculty of Medicine and Surgery, in the Philippine Islands. The enrolment there is 896. Next ranks the University of Michigan Medical School with 594 male students when the survey was made. Jefferson Medical College of Philadelphia, Georgetown University School of Medicine, Northwestern University Medical School, University of Illinois College of Medicine, Harvard University Medical School, University of Minnesota Medical School and the St. Louis University School of Medicine also reported enrolments of more than 500 students.

In 1930 medical schools graduated only 204 women. The average number of women graduates per year since 1925 has been 205. Declines in the percentage of women graduates have been reported since 1926, however. The Woman's Medical College of Pennsylvania had a larger enrolment and graduated more women in 1930 than any other medical institution in the United States. One hundred and sixteen women were enrolled, and 14 were graduated from this college.

Dr. Willard C. Rappleye was director of study of the Commission on Medical Education which was organized in 1925 by the Association of American Medical Colleges to study the medical situation in the United States. Much of the information and statistics gathered is incorporated in this report.

DELEGATES TO THE NINTH INTERNATIONAL DAIRY CONGRESS

THE following delegates have been appointed by Secretary Hyde, and their nominations approved by the Department of State, to represent officially the United States at the Ninth International Dairy Congress, to be held at Copenhagen, Denmark, from July 14 to 17: From the department, O. E. Reed, chief of the Bureau of Dairy Industry; Nils A. Olsen, chief of the Bureau of Agricultural Economics, and R. R. Graves, chief of the division of dairy cattle breeding, feeding and management investigations, Bureau of Dairy Industry; Dr. C. H. Eckles, chief of the department of dairy husbandry, University of Minnesota; Professor M. Mortensen, head of the department of dairy industry, Iowa State College of Agriculture; Dr. J. M. Sherman, head of the department of dairy industry, Cornell University; C. E. Gray, president, Golden States Milk Products Company, San Francisco; O. F. Hunziker, director of research, the Blue Valley Creamery Butter Company, Chicago; Dr. E. V. McCollum, professor of biochemistry, the Johns Hopkins University, and C. L. Hill, chairman of the Wisconsin State Department of Agriculture. They will sail from New York on July 1, on *The George Washington.* The international dairy congresses are organized by the International Dairy Federation to help bring about cooperation by the dairy industries of all countries in promoting technical and scientific development of the industry throughout the world. Nine have been held since 1903—at Brussels in 1903, Paris, 1905, The Hague, 1907, Budapest, 1909, Stockholm, 1911, Bern, 1914, Washington, 1923, Paris, 1926, and London, 1928.

THE AMERICAN PHILOSOPHICAL SOCIETY

AT the annual meeting of the American Philosophical Society, held in Philadelphia on April 23, 24 and 25, the following members were elected:

Arthur Francis Buddington, associate professor of geology, Princeton University.

Ermine Cowles Case, professor of historical geology and paleontology, University of Michigan.

William Crocker, director of the Boyce Thompson Institute for Plant Research, formerly of the department of botany, University of Chicago.

Raymond Smith Dugan, professor of astronomy, Princeton University.

Alexander Forbes, associate professor of physiology, Harvard Medical School.

Simon Henry Gage, professor emeritus of applied histology and embryology, Cornell University.

Evarts B. Greene, professor of American history, Columbia University.

Alfred F. Hess, pediatrician, New York City.

Ernest A. Hooton, professor of physical anthropology, Harvard University.

Dugald Caleb Jackson, head of the department of electrical engineering, Massachusetts Institute of Technology.

Carl Otto Lampland, astronomer, Flagstaff Observatory, Arizona.

Waldo G. Leland, author and permanent secretary of the American Council of Learned Societies, Washington, D. C.

Wesley Clair Mitchell, professor of economics, Columbia University.

Alexander G. Ruthven, president of University of Michigan and director of the Zoological Museum.

Herman Augustus Spoehr, director for natural sciences, the Rockefeller Foundation.

Ernest Edward Tyzzer, professor of comparative pathology, Harvard University.

Willis R. Whitney, director of research laboratory, General Electric Company, and vice-president in charge of research since 1928.

Leicester Bodine Holland, architect, chief of the Division of Fine Arts, Library of Congress, and professor at the University of Pennsylvania.

Howard McClenahan, physicist, secretary and director of the Franklin Institute.

J. Henry Scattergood, Assistant Commissioner for Indian Affairs.

Walter S. Gifford, president of the American Telephone and Telegraph Company.

John D. Rockefeller, Jr., New York City.

Adolph S. Ochs, publisher of *The New York Times.*

Frank B. Kellogg, of the World Court and formerly Secretary of State.

Dwight W. Morrow, United States Senator from New Jersey.

The foreign members elected were:

Arthur Stanley Eddington, professor of astronomy, University of Cambridge.

Sir Arthur Keith, conservator of the Museum and Hunterian professor, Royal College of Surgeons of England.

Dr. Henry Norris Russell was elected vice-president, and the following officers were re-elected: Dr. James H. Breasted and Dr. Elihu Thomson, vice-presidents; Dr. Arthur W. Goodspeed and Dr. John A. Miller, secretaries; Dr. Albert P. Brubaker, curator, and Eli Kirk Price, treasurer. Mr. James M. Beck, Dr. Francis G. Benedict, Dr. Edwin G. Conklin and Dr. Lafayette B. Mendel were chosen as councilors to serve three years.

SCIENTIFIC NOTES AND NEWS

Dr. Thomas Hunt Morgan has been elected a corresponding member of the Paris Academy of Sciences in the section for anatomy and zoology.

The honorary doctorate of philosophy of the University of Berlin was conferred on Dr. R. W. Wood, professor of experimental physics at the Johns Hopkins University, at the German Embassy in Washington on April 27.

The University of Cambridge will confer the honorary doctorate of science on Professor J. S. Haldane, director of the Mining Research Laboratory at the University of Birmingham.

Honorary degrees conferred by the University of Aberdeen on April 3 include the doctorate of laws on Sir Leonard Erskine Hill, lately professor of physiology at the London Hospital and member of the senate of the University of London; on Sir Frank Edward Smith, F.R.S., secretary of the Advisory Council of the Department of Scientific and Industrial Research and secretary of the Royal Society, and on Sir J. Arthur Thomson, M.A., LL.D., emeritus professor of natural history in the University of Aberdeen.

Dr. Ernst Lindelöf, of Helsingfors, has been elected a corresponding member of the Prussian Academy of Sciences.

The Founder's Medal of the Royal Geographical Society, London, has been awarded to Mr. Bertram S. Thomas, for his geographical work in Arabia and successful crossing of the Rub Al Khali; and the Patron's Medal to Rear Admiral Richard E. Byrd, U.S.N., for his expedition to the Antarctic and his flights over both North and South Poles.

At a recent general meeting of the Geological Society of Vienna honorary membership was conferred on Mrs. Ogilvie-Gordon, "in recognition of her distinguished work on fossil corals, and especially in

connection with the geological structure of the Dolomites of the Southern Tirol."

The Petrie Medal for distinguished work in archeology has been awarded to Sir Arthur Evans.

Dr. Christian Richard Thurnwald, of the University of Vienna, has been appointed Bishop Museum visiting professor of anthropology at Yale University. Dr. Thurnwald goes to Yale to give instruction and direct research in the problems of the Pacific area under the terms of the agreement by which Yale and the Bishop Museum of Honolulu are affiliated.

Dr. Herbert M. Evans, of the University of California, was elected president of the American Association of Anatomists at the annual meeting which opened in Chicago on April 18, and Dr. George W. Corner, of the University of Rochester, was elected secretary. The next annual session will be held at the College of Physicians and Surgeons, New York, from March 24 to 26, 1932.

The following officers of the American Society of Biological Chemists were elected for the year 1931–1932 at the annual meeting in Montreal on April 9: *President,* H. C. Bradley; *Vice-president,* W. M. Clark; *Secretary,* H. B. Lewis; *Treasurer,* C. H. Fiske; *Councilor,* W. C. Rose. Officers of the American Society for Experimental Pathology were elected as follows: *President,* Samuel R. Haythorn; *Vice-president,* Peyton Rous; *Secretary-Treasurer,* C. Phillip Miller, Jr.; *Councilors,* Carl V. Weller and S. Burt Wolbach.

Dr. Lafayette B. Mendel, professor of physiological chemistry at Yale University, and Dr. E. B. Hart, professor of agricultural chemistry at the University of Wisconsin, have accepted appointment as advisers to the protein and nutrition division of the Bureau of Chemistry and Soils of the Department of Agriculture.

Dr. J. Bartels, professor of meteorology at the Forstliche Hochschule, Eberswalde, Germany, known for his theoretical investigations of the earth's magnetism, has been appointed a research associate in the Department of Terrestrial Magnetism of the Carnegie Institution of Washington. He took up this work on April 1. Dr. Bartels is devoting his attention principally to the interpretative discussion of the large amount of observational material accumulated by the Department of Terrestrial Magnetism.

Dr. Douglas W. Macomber, Denver, has been appointed scientific editor of *Colorado Medicine,* succeeding Dr. John Rosslyn Earp, who resigned to become director of public health of New Mexico.

Dean Albert R. Mann, of the New York State College of Agriculture at Cornell University, has been elected chairman of the committee on rural and village housing, one of several groups comprising the White House Conference on Home Building and Home Ownership.

Among the members of the British Committee of Inquiry into Calendar Reform are the Astronomer Royal, Sir Frank Dyson; Professor Winifred Cullis, of the University of London; Sir Herbert Walker, Lord Riddell, Sir Basil Kemball-Cook, Sir Stanley Machin and Mr. A. G. Walkden, M.P.

For the purpose of geomorphologic field study Professor Frank J. Wright, head of the department of geology at Denison University, has obtained leave of absence for the remainder of the spring term and will accompany Professor Douglas Johnson, of Columbia University, on a trip to the Pacific Coast by way of the Gulf States. In his absence Professor Wright's work at Denison will be carried on by Professor Henry S. Sharp.

Dr. Joseph S. Chamberlain, head of the department of chemistry at the Massachusetts Agricultural College, who has been spending a year's leave of absence at Oxford, England, and in traveling on the continent, will return to Amherst at the end of June.

The *Journal* of the Washington Academy of Sciences reports that S. L. Seaton, former observer and radio operator on the *Carnegie,* expects to leave during the summer for the Huancayo Magnetic Observatory, Peru, to install equipment for an experimental radio station, for which an appropriation has now been made by the Carnegie Institution of Washington.

After a two-year search for new varieties of soybeans in Japan, Korea and Manchuria, William J. Morse, of the Bureau of Plant Industry, has returned with a collection of about 4,000 lots of seed and more than 300 samples of products made from soybeans.

Dr. Wm. A. Archer, who resigned the position of assistant pathologist of the Plant Disease Survey, U. S. Department of Agriculture, in January, 1930, to become professor of botany and plant pathology in the Escuela de Agricultura at Medellin, Department of Antioquia, Colombia, started on April 4 on an expedition into the Intendencia of Chocó, Colombia, where he expects to spend two months collecting flowering plants, fungi and insects. His headquarters will be at Quibdo.

Nine members of the Syracuse Andean Expedition arrived in Brooklyn on April 28. The group, which was sent by Syracuse University to explore Venezuela for the Syracuse University Museum of Natural Science, left New York on December 31 last under

the leadership of Dr. Parke H. Struthers, professor of zoology at Syracuse University, and director of the Syracuse Museum. The party will bring back specimens of animal and plant life of the Andean region, as well as geographical and geological data about Venezuela. Three other members of the Syracuse University faculty returned with Dr. Struthers: Dr. Ernest Reed, professor of botany; Dr. Earl Apfel, professor of geology, and Major Sidman Poole, professor of geography.

DR. HARVEY CUSHING, Moseley professor of surgery, Harvard University Medical School, Boston, delivered the William Henry Welch Lecture at Mount Sinai Hospital, New York City, on April 30, on "The Posterior Pituitary Hormone and the Parasympathetic Nervous System." Dr. Cushing gave on April 8 the Donald C. Balfour Lecture at the University of Toronto.

DR. R. G. AITKEN, director of the Lick Observatory, gave a lecture on "Recent Progress in Astronomy" in the auditorium of the new Chemical Building of the Ohio State University, on April 22. The lecture was given under the auspices of the Perkins Observatory of Ohio Wesleyan University and the Graduate School of the Ohio State University.

PROFESSOR P. W. BRIDGMAN, of the Jefferson Physical Laboratory at Harvard University, gave the invitation address in connection with the annual initiation banquet of the Wisconsin Chapter of Sigma Xi on April 22. His subject was "Physical Effects of High Pressure." On the preceding afternoon he gave a general university lecture on "The Recent Change of Attitude toward the Law of Cause and Effect."

DR. KARL F. MEYER, professor of bacteriology and director of the Hooper Foundation for Medical Research in the University of California Medical School, San Francisco, delivered the Cutter Lectures on preventive medicine at the Harvard University Medical School on April 27 and 28. His subjects were "Botulism and Its Control"; "A Safe Milk," and "Undulant Fever in the West."

DR. GEORGE H. SHULL, professor of botany and genetics at Princeton University, recently delivered the three Luther Laflin Kellogg Lectures in biology at Rutgers University, his subject being "Evening Primroses and Evolution."

THE annual Sigma Xi lecture at the University of Oklahoma was given on April 13 by Professor C. E. Mendenhall, head of the Department of Physics of the University of Wisconsin, on "Waves and Particles." Professor Mendenhall also assisted in the ceremonies at which six members of the faculty were initiated members and thirty-two graduate students were initiated associates of Sigma Xi. On Monday he addressed the Physics Colloquium and guests on the subject, "Some Recent Developments in Photoelectricity."

PROFESSOR ELLIOT SMITH, of University College, London, lectured on April 9 in Madrid on "Prehistoric Man and the Cultural Debt of the British Isles to Spain."

THE next International Congress of Applied Mathematics will be held at Cambridge, England, in the summer of 1934.

THE American Association of Pathologists and Bacteriologists plans to hold the annual session in 1932 in Philadelphia on March 24 and 25.

Industrial and Engineering Chemistry reports that the Ninth Colloid Chemistry Symposium will be held in the Chemistry Building of the Ohio State University on June 11, 12 and 13. The university extends to the members of the symposium and their families or guests the courtesies of its dormitories from Wednesday noon, June 10, to Saturday noon, June 12. The rate, including breakfast, is $1.50 per person per day. Breakfast will be served in Pomerene Hall, a building within one to five minutes' walk of the dormitories. The reception rooms of the dormitories and the University Faculty Club will be at the disposal of the members and guests. The office of the Department of Chemistry will be the headquarters room. Those desiring to avail themselves of campus accommodations should communicate with Wallace R. Brode, Chemistry Building, The Ohio State University. All other communications relative to the symposium should be addressed to W. G. France, Local Chairman on Arrangements, Chemistry Building, The Ohio State University, Columbus, Ohio.

Nature reports that the 1932 meeting of the Iron and Steel Institute will be held in the United States of America, under the presidency of Colonel Sir Charles Wright, Bart. Arrangements, with reference to ocean and inland travel, are being made with the Institute of Metals, which is also holding a meeting in the United States in 1932. The inclusive dates for the meetings and excursions are from September 12 to September 29. Plans are under consideration for participation in some form by the Canadian Institute of Mining and Metallurgy, either at Toronto or Montreal, or both.

AT a conference of individual members of the Australian delegation to the recent Imperial Economic Conference with some of the British and the Dominion authorities concerned, it was generally agreed that the proposed meeting of the Imperial

Agricultural Research Conference in 1932 could well be postponed. That has accordingly been done, and the time of the next conference and its place are at the present time in abeyance.

HARVARD UNIVERSITY has received a favorable decision under an adjudication in the estate of Stuart Wyeth, who died on December 30, 1929, which had been contested. The court awarded the residue of the estate, about $5,528,000, to the president and fellows of Harvard University, as provided by the will, together with about $300,000 in income.

THE will of Mr. James Arthur bequeathed to the Smithsonian Institution $75,000 to establish a yearly lecture on the sun, the balance of the income to be devoted to researches relating to the sun. After compromising the interests of certain heirs, the proceeds of the bequest amount to somewhat in excess of $50,000.

WE learn from the Johns Hopkins *Alumni Magazine* that the university has received gifts for the current expenses of the department of zoology; from Mr. W. P. Eno, for the fund for the "Atlas of the Fundus Oculi"; from Mr. S. Childs, for an addition to the endowment of the Institute of the History of Medicine; from Mrs. C. H. Stout, for the "following up of toxemic patients in obstetrics"; from the National Research Council, for the support of Dr. Whitehead's studies on insulating oils; from the American Child Health Association, for the support of the work of Dr. W. W. Cort in ascariasis; from the Rockefeller Foundation, for a fellowship held by Dr. E. L. Stebbins, of the School of Hygiene and Public Health.

Nature reports that the General Board of the University of Cambridge has made the following grants from the Worts Fund: £100 to the Zoological Station at Naples: £45 to Miss W. Lamb, of Newnham College, for the continuation of her excavations at Thermi; £45 to Dr. E. B. Worthington, of Gonville and Caius College, towards the expenses of the Cambridge Expedition to the East African Lakes; £45 to Dr. L. S. B. Leakey, of St. John's College, for archeological, paleontological and geological investigations in East Africa; £45 to G. Bateson, of St. John's College, for anthropological work in New Guinea; £30 to R. T. Wade, of Clare College, towards his expenses in connection with visits to museums in Europe to study fossil fish; £20 to P. W. Richards, of Trinity College, towards the expenses of a botanical expedition to the Sierra Nevada; £15 to I. H. Cox, of Magdelene College, for geological exploration in Baffin Land.

THE American Geographical Society, Carnegie Institution of Washington, Norwegian Geophysical Institution, Woods Hole Oceanographic Institution and the Cleveland Museum of Natural History are cooperating in the preparations for scientific work to be undertaken by the Wilkins-Ellsworth Trans-Arctic Submarine Expedition.

INVESTIGATIONS of the diseases of wild life have been consolidated by the Bureau of Biological Survey under a recent authorization by the Secretary of Agriculture. Dr. J. E. Schillinger, senior veterinarian of the U. S. Biological Survey, will be in charge of the work. The object is to coordinate the study of wild-life diseases, chiefly those affecting mammals and birds, and to determine the causes of outbreaks and methods of control. Laboratories will be established in Washington, D. C., and in the field, for observation and investigation of disease-producing agents and of disease conditions among animals and birds, both in the wild and under controlled conditions, as on fur and game farms.

A FURTHER adjustment in the boundaries of the Bryce Canyon National Park, Utah, is contemplated in the passage of the recent act of the Congress approved February 17. This act authorizes the president of the United States, by proclamation, to add to the park approximately 6,360 acres of public lands containing outstanding natural features which are of greater value for scenic and scientific purposes than for economic development. The act also eliminates 1,280 acres from the national park and adds them to the adjoining Powell National Forest.

DISCUSSION

ERASMUS DARWIN AND THE BIOLOGIC CONTROL OF INSECTS

IT is commonly believed that the idea of controlling insect pests through utilization of their natural enemies is a wholly modern conception, originating in the United States. That this is not altogether true is pointed out by Wheeler, 1928, in the chapter on "Insect Parasitism" in "Foibles of Insects and Men." He says:

It is only within very recent times that what may be properly called an *economic* use has been suggested for certain parasitic and predatory insects, namely, that of controlling the insects injurious to our crops, forests, domestic animals, stored foods and fabrics. The notion of using predatory beetles in destroying garden pests seems first to have occurred to Boigiraud de Potiers in France in 1843 and in the following year to Antonio Villa, in Italy. The latter country also produced two

entomologists, Rondani and Ghilioni who, during the fifties and sixties of the past century first suggested the use of parasitic insects for similar purposes (p. 50).

It is worthy of note that Erasmus Darwin, the grandfather of the illustrious Charles Darwin, pointed out clearly the possibilities of biologic control in his "Phytologia, or the Philosophy of Agriculture and Gardening," published in London in 1800.

In the course of his very careful studies on the life history and habits of plant lice, "Most curious and important animals which may in process of time destroy the vegetable world," he did not fail to take careful account of the natural enemies. Concerning the larva of the Syrphid fly he says:

> The most ingenious manner of destroying the aphis would be effected by the propagation of its greatest enemy, the larva of the aphidophorous fly of which I have given a print and which is said by Reaumur, Tom. III, Mem. 9, to deposit its eggs where the aphis abounds and that, as soon as the larvae are produced, they devour hundreds around them with no other movements but by turning to the right or left, arresting the aphis and sucking the juices. If these eggs could be collected and carefully preserved during the winter, or protected from injury in hot-houses, it is probable that this plague of the aphis might be counteracted by the natural means of devouring one insect by another; as the serpent of Moses devoured those of the magicians (p. 356).

Again, referring to the white butterflies which deposit their eggs on cabbage plants:

> Cabbage caterpillars would increase in destructive numbers, but are half of them annually destroyed by a small ichneumon-fly which deposits its own eggs in their backs. . . . This ichneumon fly should therefore be encouraged if his winter habitation could be discovered.

It is not to be expected that so keen an observer would overlook the desirability of utilizing the larger natural enemies of insects.

> All these noxious animals might be destroyed or diminished by encouraging the breed of small hedgebirds, and perhaps of larks, and rooks by not taking their nests. I have observed that house sparrows destroy the may-chafier. . . . The various species of linnets carry small caterpillars to their gaping young.

Whatever may be our estimate of the poetic ability, or the evolutionary theories of Erasmus Darwin, he may well be proclaimed the forerunner of modern economic entomologists. He discusses methods of trapping cutworms under rubbish, tree pests by trap bands and tar-paper, collecting and burning leaves to destroy the eggs of other species. He recommends the heating of grain to destroy its insect pests without injuring its germinating quality, and using hot water or steam against others. He found that the essential oils are all deleterious to certain insects, and learned by experience that while oil of turpentine would kill aphids it also killed the branches of a nectarine tree on which he used it. Arsenic, tobacco dust and tobacco fumes he used with varying degrees of success. Especially interesting were his experiments with sulphur which he used both in fumigation and in dusting, which might be accomplished with "a powder-puff, such as hair dressers use."

Particularly interesting is the fact brought to my attention some years ago by Professor C. R. Crosby that this early worker recommended the supposedly very modern lime-sulphur mixture as an insecticide.

WILLIAM A. RILEY

UNIVERSITY FARM,
ST. PAUL, MINNESOTA

A MATHEMATICAL PROOF

IN SCIENCE for January 16, 1931, it is stated that "Tropfke in the third edition (1930) of Volume 1 of his history does not furnish proof of Professor Miller's claims" relating to Babylonian mathematics. This raises the interesting question what conditions a mathematical proof must satisfy. Such a proof seems to imply not only that the arguments are correct but also that those for whom it is intended can follow these arguments completely. For instance, I have given what seems to me to be a proof of Sylow's theorem to many classes and yet I feel utterly unable to prove this theorem to one who knows nothing about the theory of groups, and this includes the great majority of the people whom I know. Similarly, proofs relating to the history of mathematics seem to imply that those for whom they are really proofs can look up the sources and verify the statements. In this sense no one can prove to me anything relating to the ancient mathematics of the Babylonians or of the Egyptians since I am unable to read their writings and can not verify that the translations thereof are correct.

One of my most noted teachers, Professor Sophus Lie, used to tell his students that he accepted many mathematical results which he had not completely proved himself but which he believed others had fully proved. He said that he felt that he had to do this in order to make rapid progress. Similarly, I would like to think that I knew some things about the ancient mathematics of the Babylonians and the Egyptians even if I am unable to go to the sources, and references to these sources seem to me to be of value only to those who can read the original writings. In particular, I am not able to determine whether the references which Tropfke gives to the division of the circle into 360 equal parts by the later Babylonians prove

the point in question since I can not read the original, but I have confidence, perhaps undue confidence, in the truthfulness of such noted scholars notwithstanding the fact that others in whom I have less confidence have made opposite statements.

Not only does the inability to read the original frequently constitute a serious difficulty in the way of using the sources as regards historical statements in mathematics but in some cases these sources are not known to exist. For instance, the original of Euclid's "Elements" is not known to be extant and yet these "Elements" are commonly regarded as very important in the history of our subject. It seems therefore that some of the most noted mathematical historians have reached conclusions which could not have been based on a study of the original documents. It is, of course, not implied here that it is undesirable to go to the sources with respect to questions relating to the history of mathematics whenever this is possible. On the other hand, it is implied that valuable conclusions have sometimes been drawn by those who have not been in position to do this. At any rate, it is well to bear in mind that a mathematical proof depends upon the knowledge relating to the subject on the part of those for whom it is intended and hence is relative, not absolute.

G. A. Miller

Urbana, Illinois

MORE ABOUT TWISTED GRAIN IN TREES

Science for February 13, 1931, contains an article by C. K. Wentworth noting the predominance of right-handed twist in spirally grained trees. Similar observations have been recorded by others. A Forest Service official on the Pike National Forest, Colorado, reports that out of 396 alpine fir trees, 85 per cent. had right-handed twist and 14 per cent. left-handed twist, leaving only 1 per cent. with straight grain. Similarly, 26 pines showed 14 individuals with right-handed twist and 4 with left-handed twist. The author also was struck with the predominance of right-handed twist when trying to find trees with left-handed twist suitable to photograph. On the other hand, in an examination of 463 Douglas fir timbers at a mill in Tacoma, Washington, he was surprised to find 94 with left-handed twist and only 8 with right-handed twist (very slight twists not being considered). The other timbers were straight grained.

No satisfactory explanation of the cause of spiral grain has yet been made. There even remains the question as to whether it is due to heredity or environment. H. G. Champion, of the Forest Service of India, reports that seed from straight-grained trees give fewer spirally grained seedlings than seed from twisted trees. The resulting grain, however, was examined only in the young stems of seedlings, and it is not certain whether the same condition would be maintained as the trees grow older.

On the other hand, Paul van Oye reports from France that trees with tap roots have no torsion, those with lateral roots have slight torsion, and those with running roots have it to a marked degree. This corresponds to the general observation that in the higher altitudes where the soil is scant and tap roots can not develop, spiral grain is much more common than in the deeper soil at lower elevations.

The frequent deduction, as made by Wentworth, that twisted grain may be due to prevailing winds acting on asymmetrical crowns is not tenable since there is no evidence within the tree trunk that actual twisting of the trunk took place after the wood was formed. Such twisting would show distinct mechanical injury to the fibers which is not found to be the case. Furthermore, the twist would be greatest near the center and least at the periphery of the trunk, assuming that it developed gradually over a period of years. Usually the reverse is the case.

Any satisfactory explanation of the cause of spiral grain must also explain why trees should be straight grained, since whatever factors are operative in keeping the fibers of most trees parallel with the axis of the trunk are modified in producing spiral grain. To say straight grain is the normal condition is not adequate, since in some hardwood species, especially in the tropics, the normal condition is for the fibers to be inclined right-handed for a number of years, then left-handed for about the same period, and then back to right-handed, and so on.

Arthur Koehler

U. S. Forest Products Laboratory,
Madison, Wisconsin

PUBLICATION OF INDUSTRIAL RESEARCH

The growth of industrial research in America and the intermingling of purely utilitarian scientific work with the so-called "pure" scientific research that may be found in many industrial laboratories raise a question of vital interest in the reporting of science to the public.

Often the achievement of a new industrial process is made known to the public through the medium of a publicity statement issued by an individual or a corporation. Often these publicity statements do not have the wealth of detail that characterizes the publication of a scientific paper. The circumstances surrounding a technical development are often highly complicated. A patent may be pending. Or for other reasons the heads of the organization paying for the research do not wish to reveal the scientific and technical details of the process or the invention.

The announcement of the discovery or invention often is limited to a plain statement of claims without any explanation of how the new development has been obtained.

Notable examples in recent months include:

(1) The announcement of durium, the synthetic plastic of which the fifteen-cent "Hit of the Week" phonograph records are manufactured. The publicity on this development simply stated that a new and suitable plastic had been developed, and the materials used and the composition of the plastic were not revealed.

(2) The carbon monoxide removing attachment for automobiles developed by Dr. J. W. C. Frazer, of the Johns Hopkins University. What this device does was told in the announcement, but how it operates and the composition of the materials contained in the cannister were not made public.

(3) The development of a super-speed motion picture film by the Eastman Kodak Company. The benefits to be derived from the use of this film, soon to be placed on the market, were elaborated, but no technical information about the emulsion or the research that led to the development of this speedy emulsion could be obtained from the company even after it was pointed out that this information would be desirable.

Such instances will undoubtedly multiply in the coming months and years.

It is recognized that for the commercial protection of some of the companies supporting research there must be some instances in which it is impossible to reveal the technical details and steps of the scientific procedure that led to the discoveries and inventions being exploited commercially.

In many cases, however, lack of scientific detail is not due primarily to the fear of revelation of any material which would interfere with commercial exploitation or the obtaining of a patent. It seems to arise from the fact that many of the announcements are prepared and visaed by the sales, advertising and other purely commercial departments of the company supporting the research.

It is not proposed that the commercial side of an industry be relegated to a position of absolute subordination to the research laboratories and the scientists employed. But it is suggested that the progress of science and the understanding of science on the part of the general public will be accelerated if scientists in industrial work will insist, so far as possible, that publicity reports of their work be as carefully prepared and as revealing as reports intended for publication in scientific and engineering journals.

WATSON DAVIS

SCIENCE SERVICE

THE LIFE OF BOOKS

[Apropos of the reference to "Life of Books" in SCIENCE, Feb. 27.]

THIS has long been a subject of great concern to librarians, under our present system of heating, the most of which is unhygienic, as practicing physicians and others will confirm, from the time of Franklin.

The disintegration of bindings I find largely confined to leather, particularly the Russian leather type. There is, however, in my library a wonderfully preserved volume, bound in human skin, in 1861—the skin from a soldier who died in the Civil War. This has completely resisted the effect of both the steam and hot water system of heating, and is in as perfect condition to-day as when bound in '61.

In a voluminous scientific correspondence which covers the period 1838–1891, the only writing paper which shows disintegration in the whole series of letters is the blue paper used by the Smithsonian Institution, principally letters of Joseph Henry and Spencer F. Baird during the 50's and 60's of the last century.

JOSEPH LEIDY II

REPORTS

THE MILTON AND CLARK AWARDS AT HARVARD UNIVERSITY

AWARDS amounting to more than $60,000 have been made from the Milton and Clark Funds to members of the teaching staff of Harvard University to enable them to carry on research during the academic year 1931–32. The following list contains the names of those to whom the awards in the physical and biological sciences have been made and a statement of the purposes for which the grants will be used.

Henry E. Bent, instructor in chemistry, for study of the electron affinity of a number of organic free radicals in order to obtain quantitative data relative to the valence of carbon.

Raoul Blanchard, professor of geography, for continued geographical exploration field-work along the north shore of the St. Lawrence estuary from Quebec to the Strait of Belleisle.

Nicholai A. Borodin, curator of fishes, for study of the "Anabiosis" or the phenomenon of resuscitation of fishes after being frozen.

Paul E. Boyle, instructor in operative dentistry, for study of the circulation of the dental pulp.

William J. Clench, lecturer on zoology, to collect

in the Florida Everglades the highly specialized molluscan fauna modified to live in the trees of the isolated hammocks.

Lemuel R. Cleveland, assistant professor of protozoology, for study of the wood-feeding roach, *Cryptocercus punctulatus* Scudder.

Carleton S. Coon, associate in anthropology, for rewriting and bringing up to date Ripley's "Races of Europe."

Reginald A. Daly, Sturgis Hooper professor of geology, Kirtley F. Mather, professor of geology, Donald H. McLaughlin, professor of mining engineering, and L. Don Leet, instructor in seismology, for study to determine the elastic constants of rocks for the Quincy and Westerly granites by measuring the velocity of transmission of vibrations from dynamite blasts.

Walter F. Dearborn, professor of education, for the construction of a stereoscopic optometer to study differences in the eyes of school children who have difficulty in learning to read.

Merritt L. Fernald, Fisher professor of natural history, to map the ranges of living plants as important checks on historical geology.

Willard J. Fisher, lecturer on astronomy, and Harlow Shapley, Paine professor of practical astronomy, to help finance a scientific investigation of meteors in Arizona.

Edward W. Forbes, director of the Fogg Art Museum, to develop a technique for the transference of Asiatic wall paintings and study the properties and application of varnishes and other protective coatings as a means of preservation.

Russell Gibson, instructor in geology, to correlate a series of sedimentary rocks in the Northwest, determine the relationship of certain intrusive igneous rocks to the central Idaho intrusive, determine the origin of the ore deposits, and discover the extent of glaciation and the possible modification of the gold-bearing stream gravels by glaciers.

Louis C. Graton, professor of mining geology, to build a precision photographic microscope for the study of "opaque" materials by polarized light.

George B. Kistiakowsky, assistant professor of chemistry, to study the oxidation of gaseous hydrocarbons, particularly the oxidation of acetylene, so as to derive a kinetic interpretation.

Alexander McAdie, Abbott Lawrence Rotch professor of meteorology and director of the Blue Hill Observatory, for the further development and installation of a thermodynamic thermometer.

Henry A. Murray, Jr., assistant professor of abnormal and dynamic psychology, to study the psychology of humor, and the relationship between certain psychological and physiological processes.

Ralph B. Perry, Edgar Pierce professor of philosophy, to record the thought and character of William James, as revealed in unpublished correspondence, notes and marginalia.

Gregory Pincus, instructor in general physiology, to investigate the nature of the development of the temperature-regulating mechanism in mice, and record the various interrelated phenomena.

Percy E. Raymond, professor of paleontology, to study Paleozoic myriapods and Paleozoic crustaceans, other than trilobites, in England, Scotland and Ireland.

Lawrence D. Redway, associate in anthropology, to initiate investigation looking toward the creation of a new and accurate color scale for the anthropologic classification of eye structure and pigments by means of color photography.

Albert Sauveur, Gordon McKay professor of metallurgy and metallography, to purchase a Southwark 60,000-pound Universal testing machine.

Marshall H. Stone, assistant professor of mathematics, for expenses incurred in preparing for publication a manuscript on "Linear Transformations in Hilbert Space."

Morgan Upton, instructor in physiology and in psychology, for investigating temperature changes in active nerve tissue at the laboratory of Professor A. V. Hill in London.

Robert DeC. Ward, professor of climatology, to prepare for publication data on the climatology of the United States, Mexico and the West Indies, as a contribution to a new *Handbuch der Klimatologie*.

Ralph H. Wetmore, assistant professor of botany, to make collections in Panama to facilitate the further study of phylogeny in the angiosperms.

Robert H. Woodworth, instructor in botany, to investigate the origin and development of vessels in seed plants as bearing on the question of phylogeny of plant groups.

Jeffries Wyman, Jr., instructor in zoology, to study the dielectric properties of amino acids and proteins.

The Milton Fund, created by the will of William F. Milton, '58, came into the possession of the university in 1924. Under the terms of that bequest, the income must be used "in the interests of, or for promoting, the physical and material welfare and prosperity of the human race, or to assist in the discovery and perfecting of any special means of alleviating or curing human disease, or to investigate and determine the value or importance of any discovery or invention."

This is the first year in which grants from the Clark Fund have been available. It is founded on a bequest from Joseph H. Clark, '57, who provided that "the income shall be devoted to the encouragement and advancement of original research."

Dr. Frank B. Jewett, electrical engineer, of New York City, and Professor Edwin F. Gay and Professor William M. Wheeler, both of Harvard, make up the committee to advise the president and fellows in selecting purposes for which grants are made.

SCIENTIFIC APPARATUS AND LABORATORY METHODS

A MODIFIED FORM OF KUNDT'S TUBE

IN this form of Kundt's tube the air column is set in vibration by a reed from a mouth organ; the reed being actuated by a blast of air. The cork to which the reed is attached is moved back and forth in the glass tube by means of a hollow brass rod which also conducts the compressed air to the reed. At the nodes the vibration of the reed is dampened while

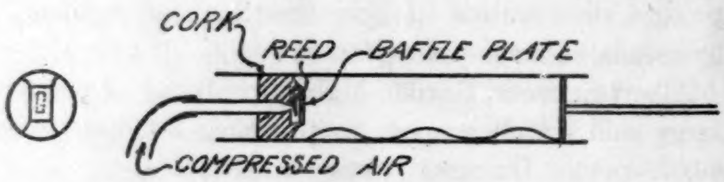

FIG. 1

at the loops, the intensity increases greatly. Thus a large class can listen to the change in intensity. The shadows of the cork particles in vibration may also be projected upon a screen. The success of this instrument is due to the introduction of a baffle plate in front of the reed by Lee Fullmer of our laboratory. This leaves two small rectangular openings in front of the reed, which are actually the sources of the vibrations transmitted to the air column. Therefore as the reed is moved back and forth it never quite ceases its vibration as it would do if unprotected. The cork which holds the reed fits loosely in the glass tube so that air escapes past it when the compressed air is turned on.

R. C. COLWELL

DEPARTMENT OF PHYSICS,
WEST VIRGINIA UNIVERSITY

AN INEXPENSIVE GLASS MARKING PENCIL

A VERY satisfactory substitute for the diamond pencil generally used for marking glassware may be easily made from an ordinary file. A six-inch round file is most convenient, but the triangular variety will serve. To make the pencil, the tang of the file is broken off, and the large end of the body is ground to a point. It is then heated to a bright red, and rehardened by plunging into mercury. Triangular points with sharply cut facets have given the best results of the various styles tried. Round points require heavier pressure for marking and appear to be less durable. It is important that the slope be rather short and that the angle between facets at the point be not less than ninety degrees. Long sloping needle-like points have a gouging action that makes neat marking impossible. About an inch of the file should be heated in a Fisher burner, and the cutting point should be kept out of the flame till the portion back of it is red-hot. The hardening operation is best done in a hood to avoid danger of inhaling mercury vapor. A pyrex test-tube is convenient for holding the mercury, and if a number of the pencils are being made, it may be placed in a water or ice bath.

The writer has tested a number of these markers in comparison with a splint diamond and one of the new tungsten carbide pencils, and has found them entirely satisfactory. It is to be expected that the steel pencils will be less durable than the diamond or the tungsten carbide markers, but they will apparently outlast the ordinary carborundum point. One of them has been used for making over five hundred single letters or figures without marked evidence of wear, while another which was not retempered but was ground carefully to maintain the hardness of the file made barely a dozen. The cost is but a fraction of the usual price for the other pencils, and a worn point can be resharpened or a new one made in about ten minutes.

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SPECIAL ARTICLES

THE EFFECTS OF ULTRA-VIOLET LIGHT ON PARAMAECIUM

PROBABLY one of the most interesting problems which has ever presented itself to the physicist and the biologist alike is the effect of ultra-violet light on organisms of all kinds. Little effort seems to have been directed, however, on the well-known infusoria *Paramaecium*. In a series of experiments recently performed by the writer a number of interesting phenomena were observed.

The source of light was a one and a quarter ampere mercury vapor arc lamp with a corex glass bulb containing a window less than two one-thousandths of an inch in thickness. The ultra-violet obtained had a wave length of from 2,500 to 3,650 angstrom units. There was a little visible light given off but practically no heat. The *Paramaecium* were placed in a cavity slide with the water about two millimeters thick and at a distance of about two inches from the window of the tube so that they could be watched through the microscope during the exposures. The following results were noted:

(1) The *Paramaecium* becomes shorter and much thicker. After about half a minute of irradiation under these conditions a limit is reached at which time the *Paramaecium* is about three quarters its original length, the diameter being larger as a result.

(2) The cell wall is shown to be composed of at least two layers which separate to form a sort of blister. This took about one and a half minutes' total exposure. That there is a distinct cell wall between the blister and the interior of the *Paramaecium* may be shown by the fact that the cytoplasm can be seen entering the blisters which before were quite clear and free of all matter.

(3) The proteins of the cytoplasm coagulate. Thus the food vacuoles and contractile vacuoles, etc., which were clear and sharp, become indistinct and undifferentiated.

(4) The outer wall finally breaks, letting the coagulated cytoplasm into the surrounding liquid where it disintegrates.

(5) Perhaps of most interest, the *Paramaecium* fluoresce a pale violet color when living but seem to lose this property when dead. This may best be seen when the field is illuminated with a yellow light at the same time that the ultra-violet is turned on the *Paramaecium*.

(6) After having been exposed for about half a minute, although the *Paramaecium* do not die immediately, they will not live more than two or three hours and will never divide or continue growth—due probably to the fact that the life processes are stopped by the coagulation. It was found that specimens which had partly divided by simple fission stopped at whatever stage they were and died several hours later having been exposed for only half a minute.

(7) Most of the specimens threw out a tremendous number of trichocysts.

L. B. Rentschler

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THE NORTH AMERICAN LUNG FLUKE

Although the lung fluke, *Paragonimus*, has been reported from cats, dogs and pigs in this country since 1894 the life history, until the present time, has been unknown. In the course of studies on the parasites of our native mink, *Lutreola vison*, it was found that this fluke is not uncommon and at the suggestion of Dr. W. A. Riley a study of the life history was begun.

A wide variety of aquatic animals serving as food for mink was taken into consideration, but since various species of fresh water crabs and crayfish act as an intermediate host of the Asiatic lung fluke, *P. westermanni*, particular attention was devoted to the native *Astacidae*. These were often found to harbor immature flukes and during the summer of 1930 a single specimen, regarded as possibly *Paragonimus*, was found in a *Cambarus* from a small creek near Minneapolis. On November 11, 1930, large numbers of distome metacercariae agreeing closely with Kobayashi's[1] description of those of the Asiatic lung fluke were found in *Cambarus immunis spinirostris*[2] from the same creek. Since then particular attention has been devoted to these larval forms.

The cysts are spherical and transparent, measuring 2.5 mm to 5 mm in diameter. The enclosed larvae are sometimes folded and sometimes straight. When excysted their length varies from 0.5 mm to 2 mm depending on the degree of contraction. They are covered with minute spines and each possesses a large boring spine on the dorsal side of the oral sucker. The intestinal rami are striking in their similarity to the large convoluted rami of the adult *Paragonimus*. The excretory bladder is a large, conspicuous, unbranched sac extending anterior to the acetabulum and filled with highly refractive globules. A short distance posterior to the acetabulum two small ducts extend laterad from the bladder, each one bifurcating into an anterior and a posterior branch. The characteristic red color noted for the metacercariae of *P. westermanni* is lacking.

Thirty-two per cent. of the crayfish examined from the creek in question were infected. The cysts varied in number from 1 to 8 and without exception were found in the pericardial cavity.

These cysts were fed to two cats, the first cat receiving 35 between November 13 and 17, and the second receiving 30 between November 25 and 27. The animals used were reared on the experimental ranch of a commercial animal food company and had no access to aquatic animals. In the laboratory they were fed a commercial preparation, milk and liver. Frequent fecal examinations over a period of six

[1] Kobayashi, Harujiro, "Studies on the Lung Fluke in Korea. I. On the Life History and Morphology of the Lung Fluke," Mitt. Med. Fachschule zu keijo, 97–115, 1918.

[2] The writer is indebted to Dr. Samuel Eddy for the identification of this crayfish.

months had shown light roundworm infections but no trematodes.

January 5, 1931, both cats were coughing badly and eggs of *Paragonimus* were found in the feces of the one first fed. The second and apparently more severely affected animal was killed. Examination revealed 24 young flukes, measuring from 4 to 6 mm in length, encysted in pairs in the lungs. Although no eggs were yet being produced, stained and cleared specimens left no doubt as to their being *Paragonimus kellicotti*.

It is thus evident that at least one species of our native crayfish serves as second intermediate host of the lung fluke. Further studies on the life history and significance of the parasite in North America are being undertaken as a cooperative project of the departments of zoology and of entomology and economic zoology at the University of Minnesota.

FRANKLIN GERHARD WALLACE
UNIVERSITY OF MINNESOTA

A PRELIMINARY NOTE ON THE OCCURRENCE OF A COLOR MUTATION IN THE HOUSE MOUSE (MUS MUSCULUS)

THE known genes of the mouse, *Mus musculus*, are more numerous than those of any other member of the rodent order, although there are still several known genes in other species of rodents which have not as yet been observed to mutate in mice. Animal experimenters are continuously on the watch for inherited variations in any of the visible characters of their stocks, and, since the occurrence of detectable mutations is rare in mammals, it is of interest to find a color character in a highly inbred strain of mice which has not, to our knowledge, occurred before.

This inbred strain of control animals has been produced in these laboratories by progressive matings from one pair of animals. The present stock is made up of animals which have been bred by brother-sister, or back-cross to father, matings and are now 20 or more generations removed from the original parent animals. The genetic constitution of this strain is given as aabbCCDDPP, etc., by the symbols of the American Mouse Club. Phenotypically these animals have a chocolate brown coat which is solid except for an irregularly occurring white patch on the ventral surface of the trunk or on the tail.

In the later part of August, 1930, two color mutants were observed among the progeny of these chocolate brown mice. The mother of these animals, ♀10367, had been mated to her brother, ♂10368. A sister, ♀10366, produced a litter by the same male in which there were four phenotypically normal animals. Three of these young (♀11045, ♀11044 and ♂11042) were mated brother to sister.

In October female 11045 gave birth to a litter of four young, two of which were apparently identical in color with the previously observed mutants.

The chocolate brown strain of mice from which these animals have appeared has bred true to color since its origin from heterozygous black (Bb x Bb) parentage 20 generations previous to the present occurrence. The new mutant animals resemble somewhat the dilute brown mice (ddbbaa) which are a familiar laboratory strain. They are of a lighter shade than these animals, the lightness being pronounced on the ventral surface of the body and around the head. No difficulty is encountered in distinguishing the mutants from the ddbbaa animals.

The mutant animals are fertile and breed true. The new color character has been tested and found not to be in the Dd (intense, dilution) or the C c^{ch} c^{d} c (color, chincilla, extreme dilution, albino) allelomorphic groups, and is recessive to the presence of chocolate brown.

The character is being tested and will be reported more fully.

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BOOKS RECEIVED

BRADLEY, J. CHESTER. *A Manual of the Genera of Beetles of America North of Mexico.* Pp. x + 360. Plates. Daw, Ilston.

CLARK, AUSTIN HOBART. *A Monograph of the Existing Crinoids. The Comatulids. Volume I, Part 3.* Bulletin of the U. S. National Museum, Smithsonian Institution, No. 82. Pp. vii + 816. Plates. Government Printing Office. $2.00.

JEFFREYS, HAROLD. *Scientific Inference.* Pp. vi + 247. Cambridge University Press, Macmillan. $3.25.

KEYSER, CASSIUS J. *Humanism and Science.* Pp. xx + 243. Columbia University Press. $3.00.

National Research Council. Bulletin No. 77. Physics of the Earth—Volcanology. Pp. vii + 77. *Bulletin No. 78. Physics of the Earth—II—The Figure of the Earth.* Pp. iv + 286. *Bulletin No. 79. Physics of the Earth—III—Meteorology.* Pp. xi + 289. National Academy of Sciences.

PATTEN, BRADLEY M. *The Embryology of the Pig.* Second edition. Pp. x + 327. 168 figures. Blakiston. $3.50.

SHERMAN, H. C., and S. L. SMITH. *The Vitamins.* Pp. 575. American Chemical Society Monograph Series. Chemical Catalog Company. $6.00.

WOODWORTH, ROBERT S. *Contemporary Schools of Psychology.* Pp. vi. + 232. Ronald Press. $2.50.

Errata: Dr. Karl Landsteiner requests that the following corrections be made to his article appearing in the issue of SCIENCE for April 17:

Page 406, first column, line 7: In place of "isoantibodies," read "immune isoantibodies."

Page 408, second column, line 4: In place of "tumors," read "ulcers."

Page 409, first column, line 7: In place of "which," read "who."

Page 409, second column, line 7: In place of "protein," read "proteins."